CLAIMS

What is claimed is:

1. A method for generating, and evaluating, property estimation grids for use with a dielectrometer for measuring preselected properties of a material comprising the steps of:

a) defining electrical, physical, and geometric properties for a material including preselected properties of the material;

b) defining operating point parameters and an electrode geometry, electrode configuration, substrate material and dimensions, and electrical source excitation for the dielectrometer;

c) inputting the material properties, the operating point parameters, and the dielectrometer electrode substrate geometry, configuration and source excitation into a model to compute and input/output terminal relation value;

d) recording in a database the terminal relation value as a property estimation grid point;

e) adjusting the preselected properties of the material and repeating steps c) and d).

2. A method as claimed in Claim 1 where the additional step is added of f) analyzing the resultant grid(s) to determine their numerical properties and properties as mappings between measurement and property spaces to allow their comparison, determination of fitness for various measurements and the implications upon the whole measurement strategy, and to allow selection among grid and measurement alternatives

3. A method as claimed in Claim 1 wherein the terminal relation values of part c) are transcapacitance and transconductance values; transadmittance values;

transimpedance values; self-admittance values; self-impedance values; complex gain; or any electrical equivalent circuit or network representation.

4. A method as claimed in Claim 1 wherein one or more of the operating point parameters in parts b) and c) are single or multiple shims of known property and geometry.

5. A method as claimed in Claim 1 wherein one of the operating point materials in parts b) and c) is a variable liquid mixture of unknown properties.

6. A method as claimed in Claim 1 further comprising the step of plotting the terminal relation values on a single or multidimensional grid.

7. A method as claimed in Claim 1 where the grid points are magnitude and phase for a single wavelength dielectric sensor.

8. A method as claimed in Claim 1 where the grid points are magnitude at one wavelength and magnitude at a second wavelength.

9. A method as claimed in Claim 8 where the magnitude-magnitude grids are for measurements on substantially nonconducting media.

10. A method as claimed in Claim 1 where the grid points are a magnitude or phase measured with a dielectric sensor and a parameter measured with a non-dielectric sensor.

11. A method as claimed in Claim 1 wherein one or more of the operating point parameters in b) and c) are temperature dependent and variations in the temperature are used to alter the operating point.

12. A method as claimed in Claim 2 wherein step b) comprises:

defining initial dielectrometer operating point parameters and an electrode geometry, electrode configuration, substrate material and geometry, and electrical source excitation for the dielectrometer;

inputting the material properties, the dielectrometer operating point parameters, and the dielectrometer electrode geometry, configuration, substrate material and geometry, and source excitation into a model to compute an input/output terminal relation value;

adjusting the preselected properties of the material to compute another terminal relation value; computing the Jacobian elements which are measures of the variation in said terminal relation values due to the variation in the preselected material properties;

computing a singular value decomposition for the Jacobian elements to obtain singular values, singular vectors and condition number of the Jacobian elements;

evaluating sensitivity, selectivity, and dynamic range of the dielectrometer electrode and substrate structures and operating point using the singular values, singular vectors, and condition numbers for material property estimate requirements;

adjusting the dielectrometer operating point parameters and electrode geometry, configuration, substrate material and geometry, and source excitation and repeating Steps b - f until the material property estimate requirements are achieved.

13. A method as claimed in Claim 12 wherein the singular values, singular vectors, and condition number are stored with grid points to support a grid interpolation algorithm to obtain property estimates.

14. A property estimator as claimed in Claim 12 wherein the property analyzer converts each sensed electromagnetic response into a transadmittance or transimpedance magnitude and phase or equivalently into real and imaginary parts; or into equivalent electrical circuit or network representation.

15. A method as claimed in Claim 1 where the material under test is composed at least in part of a viscous material.

16. A method as claimed in Claim 15 where the viscous material is curable such as an epoxy.

17. A method as claimed in Claim 15 where the material is monitored in an on-line configuration as part of a quality control process.

18. A method for selection of a dielectrometer electrode and substrate structures and operating point for measuring one or more preselected properties of an material comprising the steps of:

a) defining electrical, physical, and geometric properties for a material including preselected properties of the material;

b) defining dielectrometer operating point parameters and an electrode geometry, electrode configuration, substrate material and geometry, and electrical source excitation for the dielectrometer;

c) inputting the material properties, the dielectrometer operating point parameters, and the dielectrometer electrode geometry, configuration, substrate material and source excitation into a model to compute an input/output terminal relation value;

d) adjusting the preselected properties of the material to compute another terminal relation value;

e) computing Jacobian elements which are measures of the variation in said terminal relation values due to the variation in the preselected material properties;

f) computing a singular value decomposition for the Jacobian elements to obtain singular values, singular vectors and condition number of the Jacobian elements;

g) evaluating sensitivity, selectivity, and dynamic range of the dielectrometer electrode structure and operating point using the singular values, singular vectors, and condition numbers for material property estimate requirements;

h) repeating Steps c - g with adjusted dielectrometer operating point parameters and electrode geometry, configuration, substrate material and geometry, and source excitation until the material property estimate requirements are achieved.

19. A method using a property estimator which accesses a property estimation grid for translating the sensed electromagnetic responses of a dielectrometer into estimates of the preselected properties of the material, the property estimator generating the property estimation grid by successively implementing a model which provides for each implementation prediction of a response for the preselected properties based on a set of properties characterizing the electrode and substrate structures and the material.

20. A property estimator which accesses a property estimation grid for translating each sensed electromagnetic response into a proximity (or lift-off) estimate, the property estimator generating the property estimation grid by successively implementing a model which provides for each implementation a prediction of a response for a particular proximity based on a set of properties characterizing the dielectrometer electrode and substrate structures and the material under test.

21. A method for generating property estimates of one or more preselected properties of a material comprising:

a) providing an electromagnetic structure capable of imposing an electric field in the material when driven by an electrical signal and sensing an electromagnetic response, an analyzer for applying an electric signal to the electromagnetic structure and sensing the response, and a property estimator for translating sensed responses into estimates of one or more preselected properties of the material;

b) defining a dynamic range and property estimate tolerance requirement for the preselected properties of the material;

c) selecting an electrode geometry, configuration, substrate material and geometry, and source excitation for the electromagnetic structure

d) generating property estimation grids for the preselected material properties and operating point response curves for operating point properties and analyzing the grids and curves to define a measurement strategy;

e) optimizing operating point properties and electrode geometry, configuration, substrate material and geometry, and source excitation, said optimizing including generating property estimation grids and operating point response curves at each operating point;

f) sensing electromagnetic response at each operating point;

g) converting electromagnetic responses into estimates of the preselected properties; and estimating property estimate technology as a function of values of the estimated preselected properties over the defined dynamic range using the property estimation grids and operating point response curves.

22. A sensor comprising:

a first and a second interdigital conductors; and

a meandering conductor which has elements which parallel the first interdigital conductor.

23. A sensor of claim 22 wherein the elements of the meandering conductor are equally spaced on either side of each of the digits of the first interdigital conductor.

24. A sensor of claim 23 wherein the ratio of the distance between the digits of the first interdigital conductor and the elements of the meandering conductor and the distance between the digits of the first interdigital conductor and the digits of the second interdigital conductor is approximately 1.6

25. A sensor of claim 23 further comprising a switching device for selecting one of the first interdigital conductor, the second interdigital conductor and the meandering conductor as a driven electrode, selecting another of the first interdigital conductor, the second interdigital conductor and the meandering conductor as a sensing electrode and selecting the last as a guard electrode.

26. A method for translating the sensed electromagnetic responses of a dielectrometer into estimates of the preselected properties of the material, comprising the steps of:

accessing a property estimation grid using a property estimator;

generating a property estimation grid for the preselected properties based on a set of properties with the property estimator; and

incrementing a model which provides for each implementation prediction of a response for the preselected properties based on a set of properties characterizing the electrode and substrate structures and the material.

27. A property estimator comprising:

an input device for receiving a sensed electromagnetic response by at least one sensor;

a property estimation grid for translating each sensed electromagnetic response into a proximity estimate; and

a property analyzer for generating an improved property estimation grid by successively implementing a model which provides for each implementation a prediction of a response for a particular proximity based on a set of properties characterizing the dielectrometer electrode and substrate structures and the material under test.

28. A method of determining properties of material under test comprising the steps of:

providing a pair of substantially identical sensors;

immersing the material under test in a first liquid dielectric;

pressing one of the sensors against the material under test;

immersing the other sensor in the first liquid dielectric and spaced from the material under test;

measuring the capacitance of each of the two sensors;

adding a second miscible liquid with a higher dielectric permittivity to the first liquid; and

comparing the capacitance of the sensors as the second liquid is added.

29. A method of determining properties of material under test of claim 28 wherein when the two capacitances of the two sensors become identical, the liquid mixture dielectric permittivity equals the dielectric permittivity of the material under test.